THE PROGRESS OF THE TELEGRAPH *

II.

ELECTRIC force pervades all matter. Our planet and the atmosphere surrounding it are vast storehouses of electrical energy in a constant state of unstable equilibrium. Electricity is one of the forces of nature, and may be developed in various ways and under various conditions. The aurora, the thunderstorm, and the earth's magnetism, are each grand displays of electrical force upon a vast scale. Electrical energy may be excited by chemical action, friction, heat, induction, magnetism; and currents of electricity so obtained may be employed for telegraphic purposes. Thermo-electricity, as the name implies, is that generated by electric currents in metallic bodies by the disturbance of the equilibrium of temperature, the essential conditions being, that the extremities of the dissimilar metals should be in opposite states as regards temperature. The discovery of thermo-electric currents is due to Seebeck of Berlin in 1821; the generation of electric currents by the application of heat to a pile or series of dissimilar metals, however, remained in abeyance until the researches of Nobili and Melloni, who constructed the thermo-electric pile, consisting of alternate parallel bars of bismuth and antimony, placed side by side. Fig. 10 is a representation of the thermo-electric pile as arranged by Melloni. The brass frame on the left contains the compound bars, the wires from the antimony and bismuth poles being connected to a galvanometer, shown on the right-hand side; the quantity of electricity passing from the poles of the pile (regulated according to the difference of temperature of the bars) causes the needle of the galvanometer to be deflected. With thermo-electric currents the quantity of electricity developed depends upon the difference of the temperature of the two poles of the dissimilar metals; the currents may be so delicate that a difference of temperature equivalent to $\frac{1}{2200}$th part of a degree may be measured.

Frictional electricity, as the name implies, is that produced by the rubbing together of certain substances. An ordinary form of the frictional electrical machine is shown at Fig. 11. It consists, first, of a hollow glass cylinder supported on brass bearings resting upon glass rods; and then of an exciting rubber of a cushion of leather stuffed with horsehair; this is mounted on glass supports, and the amount of pressure on the cylinder is regulated by screws.

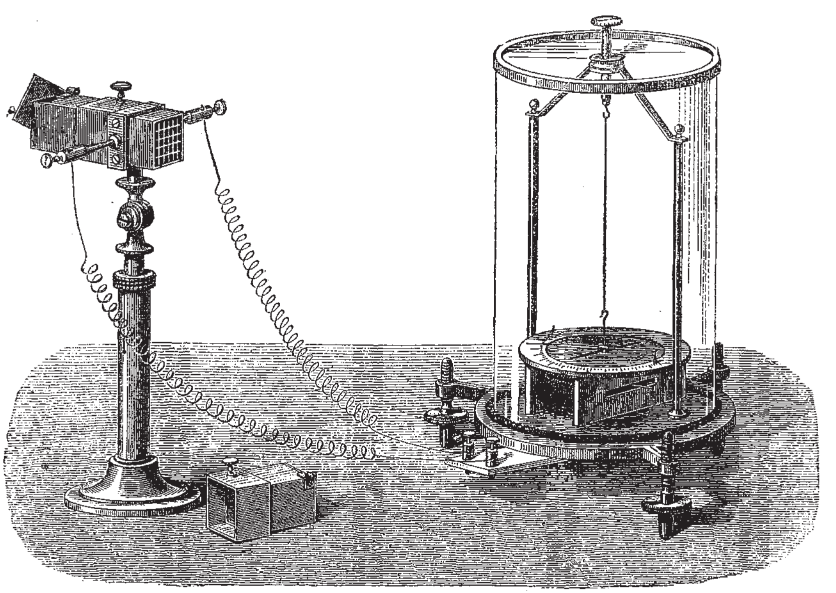

FIG. 10.—Thermo-electric pile, producing electric current by difference of temperature.

A flap of oiled silk is attached to the rubber to prevent the dissipation of the electricity from the surface of the cylinder before it reaches the points of the prime conductor, which draw the electricity from the glass cylinder on the other side. On turning the cylinder the friction of the cushion occasions the evolution of electricity, the production of which is more rapid when the surface of the rubber is smeared with a metal amalgam. When the cylinder machine is arranged for the development of either positive or negative electricity the conductor is placed with its length parallel to the cylinder, and the points project from its side as shown in the figure. The *negative* conductor supports the rubber and receives from it negative electricity by *communication*, and not by induction, as is the case with the positive conductor. If it is desired to accumulate positive electricity, a chain must be carried from the negative conductor to the ground; if, on the other hand, negative electricity is required, the conductor must be placed in communication with the earth, and the rubber insulated.

For the purpose of telegraphic transmissions, the current obtained from chemical action, or from a permanent magnet, is generally employed, and will be sufficient for the purposes contemplated in the present summary. The laws and phenomena that come into play during the propagation of an electric current require examination.

Electricity may be thus developed in the form of either a quantity or an intensity current, according to the arrangement of the elements composing the battery. A quantity current is one which, as its name implies, has great surface development. An intensity current is one of series development and of high tension. Quantity and intensity in an electric current may be combined together in different proportions, according to the work required to be performed.

As an example, suppose a battery or pile of twelve elements (Fig. 12), each element consisting of a carbon and zinc plate immersed in a glass jar containing for the exciting fluid a saturated solution of common salt. Now, if the twelve carbon plates of the series are all connected together by a common wire, and the twelve zinc plates are similarly

* Continued from p. 392.

attached, an arrangement is formed producing a quantity current, the exponent of which will be measured by the superficial area of the individual plates. Thus a current is produced of low tension but great quantity.

If, contrariwise, the zinc and carbon plates of the series are connected together alternately, an intensity current will be produced of high tension. It is thus seen that quantity and intensity may be combined together according to the disposition of the elements composing the battery. For instance, the twelve cells may be arranged either as a quantity arrangement of six cells each, connected together as two for intensity, or in groups of three for quantity, connected as four in series as an intensity current; or again, as a series of four for quantity, connected together into a group of three for intensity. It is evident, therefore, that some ratio between quantity and intensity must be determined to produce that character of current which shall be best adapted to the work to be performed. The effective force of every electric current depends therefore on two conditions—the electro-motive force or tension, and the resistance it has to overcome in passing through the metallic conducting wire. The electro-motive force of a voltaic current varies with the number of the elements and the nature of the metals and liquids which constitute each element, but is in no degree influenced by the dimensions of any of the parts. Submarine telegraphic circuits vary in length, from one mile across the Thames to 2,000 miles in a continuous stretch across the Atlantic, and a current of electric force effective for the shorter distance would be absolutely useless for the Atlantic circuit.

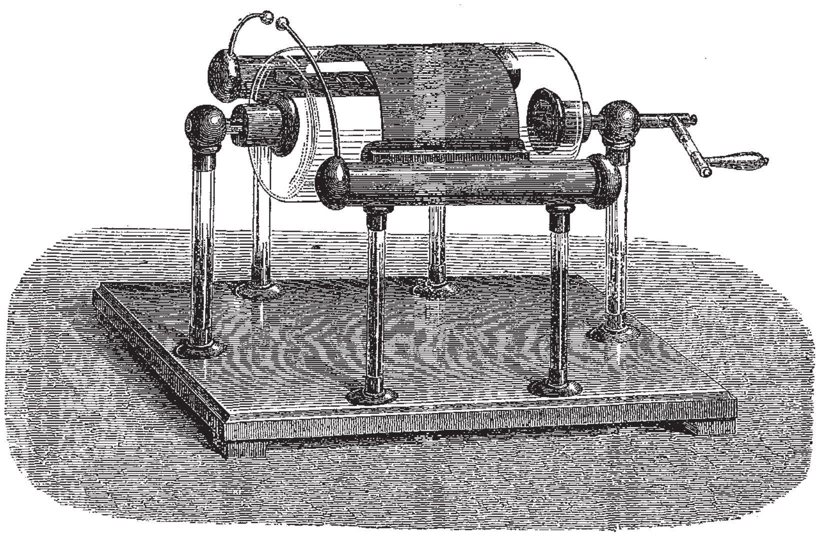

Fig. 11.—Nairne's machine, furnishing the two electricities.

The chemical power of the voltaic pile was discovered in the year 1800, and water was the first substance decomposed. If water is made a part of the electric circuit, so that a current of electricity passes through it, it is decomposed, and yields up its elements oxygen and hydrogen gases in obedience to certain laws. To decompose acidulated water it may be confined in two glass tubes (Fig. 13), sealed at one extremity, and made part of the electrical circuit by being placed over the two electrodes of the poles of the battery. Gas will then be collected in each tube, but that in connection with the positive pole of the battery will be about half the volume of that in connection with the negative pole, the former being oxygen and the latter hydrogen, as oxygen and hydrogen gases are to each other in water exactly as two to one, by volume.

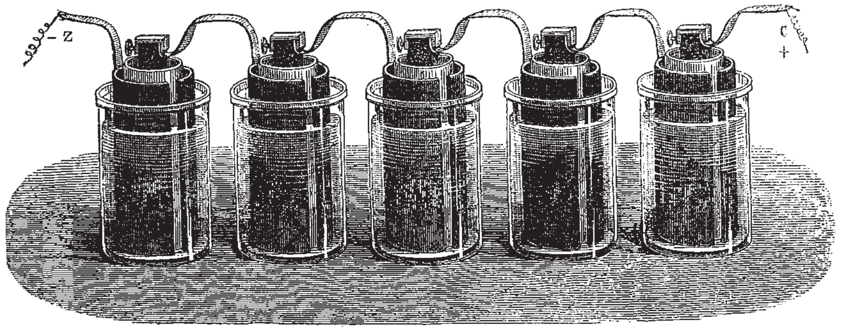

Fig. 12.—Pile formed by five Bunsen's elements.

It has already been stated that all substances, however well they may conduct electricity, offer some resistance to the passage of the current; thus, the copper conducting wire offers more or less resistance according to its length. If the resistance of a mile of the copper conducting wire is ascertained, each successive mile, if the copper is of equal purity, will have the same measure of resistance; therefore, the resistance of the copper conductor in a cable 2,000 miles long will be 2,000 times the resistance of one mile of the conductor; in other words, the resistance of the wire is in direct proportion to its length.

This is a very important fact to bear in mind, as by the measurement of the copper resistance of the conductor in a cable, a basis is at once established by which to determine the distance of a fracture. Knowing the value of the resistance of the whole length of the cable conductor —assume for 2,000 miles the value to be 2,000 units (the measure of the unit being the resistance of one mile of the copper conductor)—an interruption occurs, continuity is broken, and the copper resistance only gives 760 and 1,240 units respectively when measured from either end. Thus is clearly established a basis upon which the approximate distance of the "fault" may be ascertained. Again, it was pointed out that the insulating medium surrounding the conducting wire absorbed an appreciable amount of electricity in the passage of the current through the conducting wire. This absorption may be taken as a constant quantity, and the absorption for any length of cable be determined from given data as regards the time of electrification or the saturation of the circuit, and the time of discharge, or the percentage of leakage from the mechanical imperfections of all the insulating substances. Thus again is established a process by which, under certain conditions of injury to a cable, by correctly measuring the discharge, the position of a fault may with more or less accuracy be localised. The commercial value of a submarine cable depends upon the rapidity of its transmitting capacity, and the speed depends upon the time required to produce a variation in the tension of the current at the distant end sufficient to influence the recording instrument. The working speed depends, therefore, upon the delicacy of the apparatus employed, as then a small difference in the tension will suffice. In cables similarly constructed, but of different length, the speed of each is inversely proportional to the square of the length; because, when the length is doubled, the capacity for charge is doubled, and the electrical waves of charge and discharge have twice the distance to travel; therefore the retardation is increased fourfold. When the dimensions and weight of the insulating medium are fixed, there is a loss of speed if the conducting wire is too small; and again, if the conducting wire is too large, the speed is reduced by the increased capacity of the wire in a greater degree than it is augmented by the reduced resistance of the wire. The best accepted ratio of the insulator to that of the conductor is when the insulator is somewhat less than $3\frac{1}{2}$ times that of the copper conductor, or, more accurately speaking, in the proportion of 3·41 of insulator to 1 of copper. On long cables and where high speed is required, every current transmitted through the cable should be at equal intervals and of equal duration, so that the charge may be maintained constant between the signals.

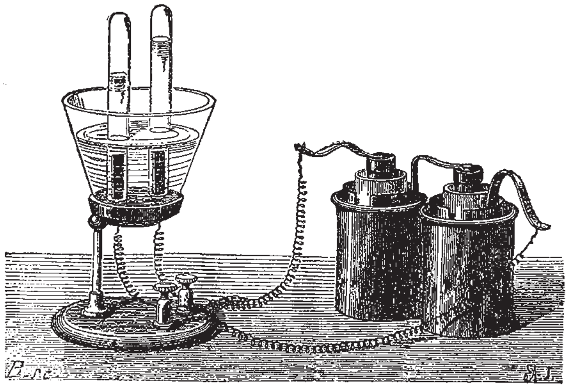

FIG. 13.—Decomposition of water by the chemical action (electro-motive force) of the voltaic battery.

(*To be continued.*)

ECLIPSE OF THE SUN, APRIL 6

As no telegram has been received from Dr. Schuster's party on its arrival at Singapore, we are compelled to estimate the date of its arrival by the telegram in yesterday's papers, which informed us that the *Pera*, in which vessel the Expedition was conveyed from Galle, arrived at Shanghai. The vessel was due there on the 3rd, and arrived on the 5th. Assuming all the delay to have occurred on this side of Singapore, Dr. Schuster's party would have reached that place on the 24th of March, which would give them ample time to reach Chulai Point and make their preparations, especially as the colonial steamer which has been detached for the service is very swift.

It is not probable that news will be received from either of the parties for some little time, as it will probably be carried by local steamers to Rangoon, Singapore, or Calcutta.

In the meantime we take the following extracts from an article in the *Times* of Tuesday, showing the final arrangements adopted so far as they are known:—

"The advantages of scientific, and especially of astronomical expeditions, are by no means confined to the record of those special phenomena which the observers go out to see. The growing interest taken by all classes in the study of nature, while it makes a large number anxious to participate in the results obtained, at the same time puts them in presence of a class of facts which the stay-at-home student finds it hard to realise for himself. The total eclipse of the sun, which is visible in the Nicobar Islands, Burmah, Siam, and Anam to-day is a case in point. While early risers are breakfasting this morning, with the beams of the sun, low down in the east, not yet able to break through the morning mists, some quarter of the way round the world there will be at least three parties of anxious observers battling with the fierce noontide heat of that same luminary nearly overhead, soon, indeed, to have his light and heat entirely withdrawn for a time, but, all the same, under conditions so different from those we are familiar with here, that the sun and the surroundings of the observers might seem to form part of another universe. Another point—and this is one which will doubtless disappoint many—is that this eclipse, which, as we stated in a former article, on the high authority of Mr. Hind, in the time of obscuration will not be surpassed by any other available one during the present century, is totally invisible here. Although there is almost total darkness for nearly five minutes in Burmah and Siam, no trace of an eclipse will be seen in these islands, for the reason that although it began as early as two minutes to four this morning, and continued till sixteen minutes past nine, the moon's shadow falls first to the south, and then to the east of us. In fact, the line of total eclipse runs from the Cape of Good Hope to Burmah and Siam, and thence to the North Pacific. We lie, therefore, in no part of the track of the shadow.

"To pass from what may be considered geographical considerations, we may remind our readers that in a former article (the *Times*, Jan. 11, reprinted in NATURE, p. 201) we pointed out the value which many men of science attached to securing observations of this eclipse, and we attempted to give a general statement of the various questions pressing for solution, which, in the opinion of the Council of the Royal Society, justified an application to the Government for aid, not only in sending out expeditions from this country, but in organising a party of observers in India. Our readers have also been informed (the *Times*, Jan. 16) of the fact that the application to Government was at once acceded to in the warmest manner, and that Sir Stafford Northcote, the Marquis of Salisbury, and the Viceroy of India, as well as the Admiralty authorities, have been unceasing in the encouragement and assistance which they